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(54) Cemented carbide body.

(57) The present invention relates to cemented carbide bodies preferably for rock drilling and mineral cutting. Due to the fact that the bodies are built up of a core of eta-phase containing cemented carbide surrounded by a surface zone free of eta-phase with low Co-content in the surface zone and successively increasing Co-content to a maximum in the outer part of the eta-phase-core they have obtained an increase in toughness and life at practical use.

Fig 1.

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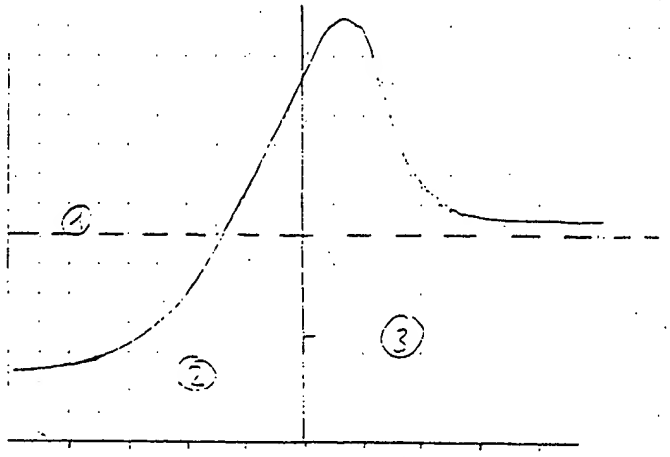


EP 0 498 781 A1

The present invention relates to cemented carbide bodies useful in tools for rock drilling, mineral cutting and in tools for road planing.

In EP-A-182759 cemented carbide bodies are disclosed with a core of fine and evenly distributed eta-phase embedded in the normal alpha + beta - phase structure, and a surrounding surface zone of only alpha + beta - phase. (Alpha= tungsten carbide, beta= binder-phase e.g. Co and eta= M_6C, $M_{12}C$ and other carbides e.g. W_3Co_3C). An additional condition is that in the inner part of the surface zone situated close to the core the Co-content is higher than the nominal content of Co (with nominal is meant here and henceforth weighed-in amount of Co). In addition the Co-content in the outermost part of the surface zone is lower than the nominal and increases in the direction towards the core up to a maximum situated in the zone free of eta-phase. The zones free of eta-phase may e.g. be created by adding carbon at high temperature to the surface zone of a body with eta-phase throughout.

Cemented carbide bodies according to the mentioned patent application have given positive increase in performance for all cemented carbide grades normally used in rock drilling. When drilling under such conditions that the outer layer of the cemented carbide is successively worn and ground away the eta-phase containing core, herein referred to as the eta-phase-core, is exposed. The risk for chipping and fracture is then increased due to the brittleness of the eta-phase.

It has now surprisingly been found that it is possible to obtain an increased Co-content in the outer zone of the eta-phase-core and thereby essentially increase the toughness of the cemented carbide.

Fig 1 shows schematically the Co-distribution along a line perpendicular to the surface of a cemented carbide body according to the invention in which:

1 - nominal Co-content

2 - surface zone free of eta-phase and

3 - eta-phase-core.

In a cemented carbide body according to the invention the Co-content increases in the zone free of eta-phase from the surface and towards the eta-phase-core. In the outermost part the Co-content is lower than the nominal. The Co-content increases to a maximum in the outer zone of the eta-phase-core and then decreases. The Co-content in the inner part of the core is often close to the nominal.

The Co-content in the outer part of the zone free of eta-phase shall be 0.2 - 0.8, preferably 0.3 - 0.7 of the nominal. The width of that part of the surface zone with lower Co-content than the nominal shall be at least 50% of the width of the surface zone, however at least 0.5 mm. In a preferred embodiment the Co-content of the whole eta-phase-free surface zone is lower than the nominal.

The Co-maximum in the outer zone of the eta-phase-core shall be at least 1.2, preferably at least 1.4 of the Co-content in the inner of the core. The eta-phase-core shall contain at least 2 % by volume, preferably at least 5 % by volume of eta-phase but at the most 60 % by volume, preferably at the most 35 % by volume. The eta-phase shall have a grain size of 0.5 - 10 µm, preferably 1 - 5 µm and be evenly distributed in the matrix of the normal WC-Co-structure. The width of the eta-phase-core shall be 10 - 95 %, preferably 25 - 75 % of the cross section of the cemented carbide body.

The invention can be used for all cemented carbide grades normally used for rock drilling from grades with 3 % by weight Co up to grades with 25 % by weight Co preferably with 5 - 10 % by weight Co for percussive drilling, 10 - 25 % by weight for rotary-crushing drilling and 6 - 13 % by weight for rotary drilling and where the grain size of WC can vary from 1.5 µm up to 8 µm, preferably 2 - 5 µm. It is particularly suitable for bits that are reground, for bench drilling bits and down-the-hole bits where the eta-phase-core comes in contact with the rock and actively takes part in the drilling.

In the binder-phase Co can be replaced partly or completely by Ni and/or Fe. Hereby the Co-fraction in the eta-phase is partly or completely replaced by some of the metals Fe and Ni i.e. the eta-phase itself can consist of one or more of the irongroup metals in combination.

Up to 15 % by weight of tungsten in the alpha-phase can be replaced by one or more of the metallic carbide formers Ti, Zr, Hf, V, Nb, Ta, Cr and Mo.

Cemented carbide bodies according to the invention are manufactured according to powder metallurgical methods: milling, pressing and sintering. By starting from a powder with substoichiometric content of carbon an eta-phase containing cemented carbide is obtained during the sintering. This is after the sintering given a carburizing heat treatment at high temperature (about 1450°C) and following rapid cooling (>100 °C/min).

Example 1

Buttons were pressed using a WC-6 weight % Co powder with 0.2 % by weight substoichiometric carbon content (5.6 % by weight instead of 5.8 % by weight). These were sintered at 1450°C under standard conditions. After sintering, the diameter of the buttons was 12 mm. The buttons were then heat treated in a furnace with

an atmosphere of CO/H_2 at 1450°C during 4 hours. The buttons were rapidly cooled in flowing hydrogen.

The buttons manufactured in this way comprised a 3 mm wide surface zone free of eta-phase and a core with a diameter of 6 mm containing finely dispersed eta-phase. The Co-content at the surface was found to be 3 % by weight. 2.2 mm from the surface the Co-content was 6 % by weight and just inside the eta-phase-core 10 % by weight.

Example 2

Bench drilling with 76 mm drill bits.

Type of rock : Diabase.
Machine : Atlas Copco Cop 1238
Feeding pressure : 45 bar.
Rotation : 35 rpm.

The bits were equipped with buttons, diameter 12 mm, with a nominal Co-content of 6 % by weight.
Variant 1: Buttons according to the invention with a structure as Example 1. The buttons had a conical top.
Variant 2: Buttons according to EP-A-182759 with a 3 mm wide surface zone free of eta-phase and a core diameter of 6 mm. The buttons had a conical top.
Variant 3: Conventional buttons with 6 % by weight Co and a conical top.

Result:	Drilled meters	Comments
Variant 1	853	Worn out diameter.
Variant 2	727	Button failures, starting from the eta-phase-core.
Variant 3	565	Early button failures and heavy wear.

Example 3

Buttons were made according to Example 1 starting with a substoichiometric carbon content of 0.24 % by weight (5.55 % by weight C) and with a sintered diameter of 11 mm. The buttons were heat treated in a CO/H_2 atmosphere at 1480°C for 3 hours and then quenched in oil at 200°C. The buttons had after this treatment a 2.5 mm wide surface zone and a core with dense, finely dispersed eta-phase together with WC and Co. The Co-content at the surface was 2.5 % by weight and 2.1 mm from the surface 6 % by weight. 0.2 mm inside the borderline between the surface zone and the core the Co-content was at its maximum about 12 % by weight. In the centre of the core the Co-content was about 6 weight-%. The buttons which had a conical top were shrink fit to 45 mm button bits of standard type.

Rock type : Lead and tin bearing sandstone with streaks of quartzite.
Machine : Montabert HC 40.
Rig : Jarvis Clarke.
Impact pressure : 150 bar.
Feeding pressure : 90 bar.
Rotation pressure : 80 bar.
Hole depth : 3.5 m.
Regrinding frequence : 28 m (8 holes).

Variant 1. Buttons according to the invention.
Variant 2. Buttons according to prior art (EP-A-182759) diameter 11 mm with a conical top.
Variant 3. Buttons according to prior art diameter 11 mm with a spherical top.
Variant 4. Conventional buttons with spherical top, diameter 11 mm and homogeneous cemented carbide with 6 % by weight Co.

Result

	Number of bits	Average drilled, m	Failures
Variant 1	8	176	Worn out diameter
Variant 2	8	108	Button failures after the third regrinding when the core was visible (after 84 m).
Variant 3	6	132	Worn out diameter and some button failures.
Variant 4	6	108	Button failures and some bits with worn out diameter.

Claims

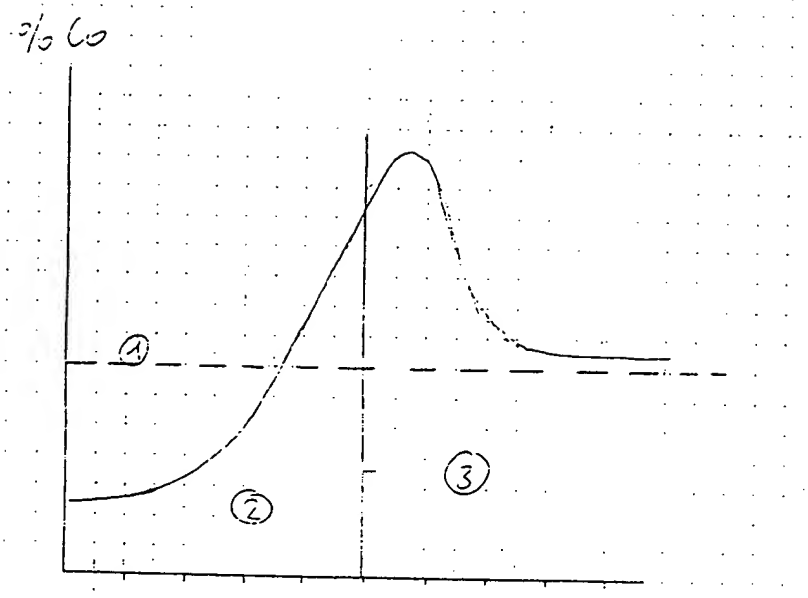
1. Cemented carbide body preferably for use in rock drilling and mineral cutting, comprising a cemented carbide core and a surface zone surrounding the core whereby both the surface zone and the core contains WC and a binderphase based on at least one of the elements cobalt, iron and nickel and the core in addition contains eta-phase and the surface zone is free of eta-phase **characterized** in that the Co-content increases in the direction of the core from lower than nominal up to a maximum inside the outer part of the eta-phase-core of at least 1.2, preferably at least 1.4 times the Co-content in the inner part of the eta-phase-core.

2. Cemented carbide body according to the preceding claim **characterized** in that the width of the eta-phase free surface zone with lower Co-content than the nominal is at least 50 % of the width of the zone free of eta-phase however at least 0.5 mm.

3. Cemented carbide body according to the preceding claim **characterized** in that the Co-content of the zone free of eta-phase is lower than the nominal.

4. Method of manufacturing a cemented carbide body according to any of the preceding claims by powder metallurgical metods such as milling, pressing and sintering whereby a powder with substoichiometric content of carbon is sintered to an eta-phase containing body which after the sintering is given a partially carburizing heat treatment whereby an eta-phase containing core surrounded by an eta-phase free surface zone is obtained **characterized** in that the carburization takes place at high temperature, about 1450°C, and following rapid cooling (>100 °C/min).

Fig 1.



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EUROPEAN SEARCH REPORT

Application Number

EP 92 85 0019

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A,D	EP-A-0 182 759 (SANTRADE LTD.) * page 4, line 9 - line 14; example 1 *	1,4	C22C29/08 C23C30/00 C23C8/20
A	EP-A-0 247 985 (SANTRADE LTD.) * claim 1; figure; example 1 *	1,4	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			C22C

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	04 JUNE 1992	ASHLEY G.W.

CATEGORY OF CITED DOCUMENTS

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